The Swan Song of a Neutron Star Binary

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2016

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Fundamental physics and astrophysics with gravitational waves from compact binary coalescence

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Abstract

Gravitational waves are surviving witnesses of the most violent events in the history of the Universe. By detecting signals from coalescing black hole and neutron star binaries we can obtain invaluable information on the properties of gravity and matter in the most extreme conditions: where matter is more dense than an atomic nucleus, spacetime is strongly curved, and its geometry evolves dynamically within fractions of a second. The recent direct detections of gravitational waves by the LIGO-Virgo Collaboration heralded the dawn of a new era of gravitational wave physics. We have now unlocked a great new sense to the exploration of the Universe, we can feel the fabric of spacetime itself vibrating, and the purpose of this doctoral work has been to study ways in which we, as physicists, can make useful sense of this unprecedented kind of information that will keep streaming through the output of our detectors. Two main themes can be distinguished in this dissertation, both related to the physics output of gravitational wave detections from coalescing compact binaries: i) testing the dynamics of general relativity in its strong, fully relativistic regime and ii) inferring the neutron star equation of state by analyzing signals from neutron star binaries. Follwing a general introduction to gravitational wave physics and data analysis, we present the formulation, and tests of methods for performing the aforementioned analyses on real data from current and future gravitational wave detectors.